Peer-reviewed paper

An instrument to measure mobile shower commode usability: the eMAST 1.0

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Abstract

Purpose – *The purpose of this paper is to present a preliminary psychometric evaluation of the electronic mobile shower commode assessment tool (eMAST) 1.0.*

Design/methodology/approach – *A cross-sectional validation study was undertaken with 32 adults with spinal cord injury (SCI), aged 18 years or older, who use mobile shower commodes for toileting and/or showering. The eMAST 1.0, Quebec user evaluation of satisfaction with assistive technology, Version 2.0 (QUEST 2.0), and modified system usability scale (SUS) were administered online via SurveyMonkey. The eMAST 1.0 was re-administered approximately seven days later. Psychometric properties of internal consistency, test-retest reliability, and convergent validity were assessed.*

Findings – *As hypothesised, the eMAST 1.0 demonstrated strong internal consistency (Cronbach's $\alpha = 0.73$, $N = 32$); acceptable test-retest reliability (intra-class coefficient (3, 1) = 0.75 (0.53-0.88, 95 per cent confidence interval) ($n = 27$)); and strong, positive correlations with the QUEST 2.0's devices subscale and modified SUS (Pearson's correlation coefficients 0.70 and 0.63, respectively).*

Research limitations/implications – *The sample was not fully representative of Australian data in terms of gender, or state of residence, but was representative in terms of SCI level. Age data were not assessed. The sample size was small but adequate for a preliminary psychometric evaluation.*

Originality/value – *The preliminary psychometric evaluation indicates the eMAST 1.0 is a valid and reliable instrument that measures usability of MSCs for adults with SCI. It may be useful for exploring relationships between usability and satisfaction of MSCs.*

Keywords *Spinal cord injury, Adults, Rehabilitation, Usability, Activities of daily living, Assistive technologies*

Paper type *Research paper*

Introduction

Adults with spinal cord injuries (SCIs) often use assistive technologies (ATs) to perform activities of daily living (Biering-Sørensen *et al.*, 2009; Harvey *et al.*, 2012; Ford *et al.*, 2014). For many adults with SCI, particularly at the cervical and thoracic levels, activities associated with showering, intimate hygiene, and managing neurogenic bowels require use of ATs such as mobile shower commodes (MSCs) (Nelson *et al.*, 1993; Friesen *et al.*, 2013, 2015c; Spinal Outreach Team, 2013; Harvey *et al.*, 2012; Ford *et al.*, 2014). Studies of adults with SCI in Australia and internationally have, however, raised concerns about the safety and usability of MSC designs (Harvey *et al.*, 2012; Malassigné *et al.*, 1993; Biering-Sørensen *et al.*, 2009; Nelson *et al.*, 1993; Friesen *et al.*, 2015c). Activities such as transferring between a bed or wheelchair and the MSC, and leaning or reaching to access showering supplies or to undertake digital stool removal and intimate hygiene, are potential causes for falls (Malassigné *et al.*, 1993; Nelson *et al.*, 1993; Friesen *et al.*, 2015c; Ford *et al.*, 2014; Spinal Outreach Team, 2013). The development of pressure injuries and skin breakdowns is associated with MSC use (Ford *et al.*, 2014; Spinal Outreach Team, 2013; Nelson *et al.*, 1993; Friesen *et al.*, 2015c). While approaches from the

Received 23 December 2015
Revised 15 February 2016
Accepted 18 February 2016

The research was supported by the University of Queensland School of Health and Rehabilitation Sciences and did not receive external funding.

human factors engineering and ergonomics domains have informed development of MSCs (Nelson *et al.*, 2000), these designs do not appear widely available (Friesen *et al.*, 2013, 2015c). Recent studies report dissatisfaction with MSCs (Harvey *et al.*, 2012; Friesen *et al.*, 2015c; Biering-Sørensen *et al.*, 2009), suggesting the design, use, and usability of MSCs remain a concern for both MSC users, and clinicians with expertise in SCI rehabilitation (Friesen *et al.*, 2015a, c).

In the broader literature, two interrelated areas have emerged in the study of AT design, use, and usability: the stages in the product development or service delivery processes where usability is assessed; and the use of generic vs AT device-specific questionnaires for assessments. Assessments of design, use, and usability of AT can occur at multiple stages: the formative and summative stages of AT product development (Choi and Sprigle, 2011; Friesen *et al.*, 2015b; Cooper, 2007; Berg Rice, 2008), as part of prescription and specification processes during AT service delivery (Arthanat *et al.*, 2009; O'Rourke *et al.*, 2014), and to measure outcomes of interventions after short- or long-term AT use (Lenker *et al.*, 2005; Arthanat *et al.*, 2007, 2009; Friesen *et al.*, 2015b). Assessments for AT devices, including MSCs, generally involve an iterative process of individualised assessment and trial, until a final specification is developed and recommended for the individual user (Cooper, 2007; Friesen *et al.*, 2015c). While many questionnaires measuring AT outcomes after short- or long-term use have considered "usability" to some degree (Arthanat *et al.*, 2007; Lenker *et al.*, 2005), they have not reported validation for use in earlier design or assessment stages (Berg Rice, 2008; Bridgelal Ram *et al.*, 2008; Lenker *et al.*, 2005). The most widely used measure in AT is the Quebec user evaluation of satisfaction with assistive technology, Version 2 (QUEST 2.0) (Demers *et al.*, 2002a). The QUEST 2.0 measures satisfaction with AT devices and services, either after service delivery, or after short- or long-term AT device use. Its capacity to distinguish or discriminate between prototypes in formative product development, or between commercialised prototypes during AT service delivery (summative product development), is not known (Friesen *et al.*, 2015b). Conversely, generic usability questionnaires can assess usability during formative and summative product development, and therefore discriminate between prototypes. In the consumer products domain, the system usability scale (SUS) (Brooke, 1996, 2013) is a widely used scale developed for this purpose. A modified version is also used for assessing usability of commercial products in summative usability testing (Bangor *et al.*, 2008). Although the SUS is considered valid and reliable for a range of consumer products, it has not been validated with AT devices (Bangor *et al.*, 2008; Sauro, 2011; Lewis and Sauro, 2009). Moreover, both the QUEST 2.0 and the SUS are generic assessment questionnaires designed for use with any product. Increasingly, experts in the design, development, and service delivery of AT recommend questionnaires be AT-device specific, and developed with input from AT device consumers to establish user-identified assessment criteria (Lenker *et al.*, 2005, 2013; Bridgelal Ram *et al.*, 2008; Berg Rice, 2008; Cooper, 2007, 2009; Mortenson *et al.*, 2007).

Questionnaires should also be validated for well-defined user groups (Lenker *et al.*, 2005, 2013; Bridgelal Ram *et al.*, 2008), and report characteristics of the AT users' disability or impairments as part of psychometric evaluations (Lenker *et al.*, 2005; Arthanat *et al.*, 2007; Bridgelal Ram *et al.*, 2008). Despite the widespread use of both the QUEST 2.0 and SUS, neither are specific to MSCs for adults with SCI. As a result, they may not capture key aspects of MSC use and usability identified in earlier research (Malassigné *et al.*, 1993; Nelson *et al.*, 1993; Spinal Outreach Team, 2013; Ford *et al.*, 2014; Friesen *et al.*, 2013, 2015c), nor provide a means to discriminate between MSC specifications or prototypes (Friesen *et al.*, 2015b, c).

To address these concerns, the eMAST 1.0 was developed to test usability during MSC design, assessment, and specification (Friesen *et al.*, 2015a, b). The eMAST 1.0 was constructed using a mixed-methods approach in five phases: interviewing key informants to identify ideal MSC features and preferences for the questionnaire's format; developing an item bank of usability indicators; constructing a preliminary questionnaire; establishing content validity with a small sample of experts in SCI rehabilitation; and constructing the final questionnaire (Friesen *et al.*, 2015a, b). This paper reports on the next stage of this study, a preliminary evaluation of the eMAST 1.0's psychometric properties, with a cross-sectional sample of Australian MSC users (Friesen *et al.*, 2015b).

Method

A prospective, cross-sectional, one-week test-retest design was used for the study. A sample size of approximately 30 participants was considered appropriate for this preliminary evaluation, based on recommendations from a review of sample sizes for survey development (Johanson and Brooks, 2010).

Participants

Participants were recruited using the following inclusion criteria: have a spinal cord injury (determined by self-report); be 18 years of age or older; use MSCs for toileting and/or showering activities (either independently or with the assistance of a carer); possess a cognitive status adequate to answer questions about using their MSC; and have access to the internet. There were no restrictions on location or gender. Participants were recruited via listservs and forums for AT users, and adults with SCI, such as those hosted by the Australia Rehabilitation and Assistive Technology Association and Spinal Cord Injuries Australia. Advertisements were also place in newsletters produced by Assistive Technology Suppliers Australasia and Spinal Cord Injuries Network Australia. Potential participants were invited to visit the survey website, where a copy of the participant information sheet and electronic consent form were available. Participants were recruited into the study once the consent form was completed.

Data collection instruments

Three instruments were used for data collection: the eMAST 1.0 (Friesen *et al.*, 2015a), the QUEST 2.0 (Demers *et al.*, 2002b), and a modified version of the SUS (Bangor *et al.*, 2008). Demographic and identifying data needed for matching responses across two time periods were also collected.

eMAST 1.0. The eMAST 1.0 measures usability of MSCs from the perspective of adults with SCI. It was developed using a mixed-methods approach incorporating a review of research, expert judgements of key MSC features and performance items, and interviews with key informants on the questionnaire's format (Friesen *et al.*, 2013, 2015a, b, c). The eMAST 1.0 contains 26 questions in three sections. The first section contains ten questions on MSC features, rated on a five-point Likert scale from 1 (very dissatisfied) to 5 (very satisfied). The second section contains 11 items covering MSC performance in use across key activities. Items are measured on a five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). The third section comprises questions on the age of the MSC frame and seat (in years), and two items for users to list three positive and three negative aspects of their MSC (Friesen *et al.*, 2015a). The first and second sections were subject to preliminary psychometric evaluation in this study. eMAST 1.0 scores were calculated for MSC Features (first section) and MSC performance (second section) by summing the scores for each item in the section, and dividing by the total number of items in the section. Items scored 0 (not applicable) were not used in the calculation. The total eMAST score was the sum of scores for both sections.

QUEST 2.0 – devices subscale. The QUEST 2.0 was designed to evaluate how satisfied user are with their assistive device and associated services they received (Demers *et al.*, 2002a, b). The QUEST 2.0 contains 12 items, rated on a five-point Likert scale of 1 (not at all satisfied)-5 (very satisfied). The QUEST 2.0 has two subscales: a devices sub-scale (items 1-8) and a services sub-scale (items 9-12). For the purpose of this study, only the devices sub-scale was used. The devices sub-sale is calculated from items 1-8, by summing the scores and dividing by the number of valid items. Items which are scored "not applicable" are considered invalid. Psychometric properties reported for the QUEST 2.0 include construct validity (expert agreement ranging from 50 to 92 per cent for all items), test-retest reliability (weighted κ ranging from 0.51 to 0.74, with average of 0.61), and internal consistency (Cronbach's αs of 0.82, 0.80, and 0.76 for 12 items, the devices subscale, and services subscale, respectively) (Demers *et al.*, 2002a, b).

SUS. The SUS, developed by Brooke (1996), is a widely used scale for assessing usability (Bangor *et al.*, 2008) (p. 189). It contains ten questions with alternative positive and negative phrasing, measured on a Likert scale from 1 (strongly disagree) to 5 (strongly agree). The SUS provides a global measure of satisfaction, with two subscales of learnability (items four and ten)

and usability (all remaining items) (Sauro, 2011; Lewis and Sauro, 2009). The wording for item 8 proposed by Bangor *et al.*, which replaces "cumbersome" with "awkward" was used (Bangor *et al.*, 2008). For the purposes of the current study, Question 4 was also modified by adding the text, "e.g. sales rep". This change ensured respondents considered the technical support and training provided by MSC suppliers and sales representatives during MSC service delivery, rather than assistance provided by paid or unpaid caregivers during activities of daily living.

The SUS is scored by first converting responses to a scale of 0-4, summing all converted responses, and then multiplying the result by 2.5 to get a total out of 100 (Sauro, 2011). In order to reduce likelihood of errors, a commercially available SUS calculator was used to generate SUS scores for this study (Sauro, 2011). The calculator includes multiple checks for possible coding and data entry errors, such as incorrect coding of positively and negatively worded items (Sauro, 2011).

Data collection procedure

The first author created all instruments as online forms using SurveyMonkey (www.surveymonkey.com). The remaining authors checked the online forms against the original instruments to identify possible coding errors. Additionally, two researchers with expertise in survey development and methodology for health research reviewed the technical implementation and wording of the online questionnaires. No concerns with online implementation were reported.

At Time 1, participants completed all three questionnaires via SurveyMonkey. At Time 2, approximately seven days later, participants were sent an e-mail asking them to complete the eMAST 1.0 a second time via SurveyMonkey. Participants were sent reminders to complete the surveys if they had not done so within seven days.

Data analysis

Data analysis of all quantitative items was conducted using SPSS for Windows version 23 (IBM Corporation, Armonk, NY). Statistical and psychometric properties were selected based on expert recommendation (Portney and Watkins, 2009) and validation work reported for the QUEST 2.0 (Demers *et al.*, 2002a, b).

The study's hypotheses were that the eMAST 1.0 would demonstrate:

- strong internal consistency, determined by measuring a Cronbach's $\alpha \geqslant 0.70$, among the items (Portney and Watkins, 2009);
- acceptable test-retest reliability, determined by an intra-class coefficient (ICC), Model (3, 1), of $\geqslant 0.70$ for the overall scale (Portney and Watkins, 2009); and
- good to excellent convergent validity with items from two established instruments from the AT and usability literature, demonstrated by Pearson's correlation coefficients $\geqslant 0.70$ (Portney and Watkins, 2009).

Since Pearson's coefficient is a parametric test, it requires data to be normally distributed. Prior to conducting the convergent validity analysis, the data were subject to visual inspections and the Shapiro-Wilks test for normality as recommended (Ghasemi and Zahediasl, 2012).

Ethical review

The study was approved by a local university medical ethics review committee and conducted in accordance with all requirements for research involving human subjects. Approval was obtained from each gatekeeper organisation prior to the distribution of advertisements for study participants.

Results

Data were collected between April 2014 and November 2015. A total of 32 participants completed the eMAST 1.0 at T1. Of these, 31 also completed the QUEST 2.0 and SUS. At T2,

27 participants completed the eMAST 1.0. Demographic information for all participants is shown in Table I (http://espace.library.uq.edu.au/view/UQ:399608). Among the participants, 34 per cent were female and 66 per cent were male. On average, participants were 18.6 years post-SCI (range: 2-55 years) ($n = 30$). Participants resided in five of the eight Australian states and territories.

eMAST 1.0 item response frequencies

Item response frequencies for the eMAST 1.0's 21 quantitative items are shown in Table II (http://espace.library.uq.edu.au/view/UQ:399608). Of these, six items showed the full range of possible responses. When the response of 0 (not applicable) was excluded, 12 items showed the full range of remaining possible responses. Eight items had no responses for either 1 (very dissatisfied) (item 7) or 1 (strongly disagree). A total of 13 items had responses of 0 (not applicable), including very high frequencies for tilt-in-space (item 7) ($n = 22$) and recline (item 8) ($n = 12$). A total of 50 per cent or more of respondents selected the highest score for items on arm supports (item 3) ($n = 16$) and fit in bathroom (item 15) ($n = 18$). This finding suggested the presence of ceiling effects for these items. No flooring effects were observed.

Internal consistency

Internal consistency for all 21 items, as measured by Cronbach's α, was 0.73 ($N = 32$), indicating strong internal consistency. The inter-item and item-to-total correlations are shown in Tables IIIa-b and IV (http://espace.library.uq.edu.au/view/UQ:399608), respectively.

Items regarding tilt-in-space (item 7) and recline (item 8), elicited a high number of 0 (not applicable) responses ($n = 22$ and $n = 12$, respectively). With these items removed, internal consistency remained strong (Cronbach's $\alpha = 0.76$) (Portney and Watkins, 2009). Internal consistencies of the two subscales of the eMAST 1.0, MSC features and MSC performance, were 0.67 and 0.72, respectively. After excluding items for concerning tilt-in-space and recline, internal consistency for the MSC features subscale was strong (Cronbach's $\alpha = 0.72$).

Test-retest reliability

Test-retest was completed on average 14 days apart (range 5-43 days). Table V (http://espace.library.uq.edu.au/view/UQ:399608) shows the ICCs for all 21 items. The overall ICC (3, 1) for test-retest reliability was 0.75 (0.53-0.89, 95 per cent confidence interval) ($n = 27$), indicating acceptable test-retest reliability.

Convergent validity

The mean scores of the eMAST 1.0, the QUEST 2.0 and the modified SUS are shown in Table VI (http://espace.library.uq.edu.au/view/UQ:399608). The SUS calculator flagged no potential errors in coding or data entry prior to calculating the SUS scores. Based on a visual inspection of the normal Q-Q and stem-and-leaf plots, and a result of $p > 0.05$ for the Shapiro-Wilks test for normality ($p = 0.14$), the data were considered as normally distributed (Ghasemi and Zahediasl, 2012). Pearson's correlations between the scales and subscales of each instrument also shown in Table VI. There was a significant correlation between scores on the eMAST 1.0 and the QUEST 2.0 devices subscale, r ($n = 31$) $= 0.70$, $p < 0.001$, indicating good to excellent convergent validity (Portney and Watkins, 2009). There was also a significant correlation between scores on the eMAST 1.0 and the modified SUS, r ($n = 31$) $= 0.63$, $p < 001$. Although this result indicated moderate convergent validity, it was still considered strong and positive (Portney and Watkins, 2009).

Discussion

This paper reports on a preliminary evaluation of the eMAST 1.0's psychometric properties. The eMAST 1.0 was designed to measure the usability of MSCs used by adults with SCI (Friesen *et al.*, 2015a, b). The questionnaire obtains feedback from the point of view of MSC users, and reflects

user-reported criteria captured through qualitative interviews and reviews of the literature (Friesen *et al.*, 2013, 2015a, b, c). It was developed using a standardised methodology from the literature on health measurement scales (Portney and Watkins, 2009; Friesen *et al.*, 2015b; Crocker and Algina, 1986), and demonstrated excellent content validity in an earlier study (Friesen *et al.*, 2015a). Although preliminary, the present study found the eMAST 1.0 demonstrated strong internal consistency, good test-retest reliability, strong convergent validity with the devices subscale of the QUEST 2.0 (Demers *et al.*, 2002a, b), and moderate convergent validity with a modified version of the SUS (Bangor *et al.*, 2008). Overall, the preliminary psychometric analysis reported here suggests the eMAST 1.0 is a valid and reliable scale for measuring MSC usability in adults with SCI.

Responses of 0 (not applicable) were observed for 13 items, including very high frequencies for the items concerning tilt-in-space and recline (Table II). This is to be expected since not all MSCs have all features, and not all users require those (Friesen *et al.*, 2015c). In terms of scale validation, experts recommend a closer examination of potentially redundant items for either removal or possible rewording (Portney and Watkins, 2009). Clinically, however, these items reflect indicators of MSC use and usability identified across multiple studies with key informants (Friesen *et al.*, 2015a, c; Nelson *et al.*, 1993, 2000; Malassigné *et al.*, 2000), and in Clinical Practice Guidelines developed by experts (Consortium for Spinal Cord Medicine, 1998; Ford *et al.*, 2014; Spinal Outreach Team, 2013). During the questionnaire's development, both users and clinicians indicated that such items could act as a "prompts" for discussion and reflection on an individual user's needs (Friesen *et al.*, 2015a) (p. 79). Retention of these items is recommended to facilitate the processes of individualised assessment and trial needed to develop final MSC specifications (Cooper, 2007; Friesen *et al.*, 2015c). Further, such items may prove useful for discriminating between MSC prototypes during assessment and service delivery, thereby addressing the need for such questionnaires identified earlier (Friesen *et al.*, 2015b, c). Future studies involving the eMAST 1.0 should therefore consider the clinical utility of these items in understanding MSC usability for individual users.

Cronbach's α between 0.70 and 0.90 indicate strong internal consistency of items in a scale (Portney and Watkins, 2009). The Cronbach's α for all items of the eMAST 1.0 was 0.73, suggesting the eMAST 1.0 demonstrates strong internal consistency.

The overall correlation of the eMAST 1.0 scores at T1 and T2 was ICC (3, 1) = 0.75 (0.53-0.89, 95 per cent confidence interval), ($n = 27$). Values over 0.70 indicate good test-retest stability (Portney and Watkins, 2009). The lowest correlations, with ICCs < 0.60, were calculated for seat shape (item 1), arm supports (item 3), recline (item 8), height for transfers (item 11), propelling and manoeuvring (item 13), fit in the bathroom (item 15), and MSC cleaning and maintenance (item 21) (Table V). It is possible that some respondents had multiple MSCs (e.g. one for home and one for travel) (Friesen *et al.*, 2015c), and did not consider the same MSC for both tests. The eMAST 1.0 may need wording which clarifies which MSC is being assessed, especially if multiple MSC prototypes or designs are involved. Crocker and Algina (1986) state that low coefficients raise "interesting" questions around whether the measure is unreliable, or the trait itself is unstable (p. 134). Previous research suggests that MSC use and usability can be dramatically affected by temporary or unexpected changes to a user's functional capacity (e.g. sudden illness or injury), the MSC or other AT (e.g. breakdown requiring urgent maintenance or repair), or environment (e.g. temporary accommodation) (Friesen *et al.*, 2015c). Given the longer-than-planned test-retest interval (average of 14 days vs 7 days), the lower test-retest results may indicate instability in the traits being measured. While such instability may present concerns for scale validation, the clinical relevance of such findings should not be overlooked. Temporary or unexpected changes, such as those described, may involve issues requiring urgent clinical intervention and resolution (Friesen *et al.*, 2015c). Thus, the clinical utility of these items in MSC assessments should be considered in future validation work of the eMAST 1.0.

The eMAST 1.0 demonstrated strong, positive correlation with the devices subscale of the QUEST 2.0 (Demers *et al.*, 2002a, b). Moderate correlation was shown with the modified SUS (Bangor *et al.*, 2008). These correlations suggest the eMAST 1.0 is measuring satisfaction and usability across multiple user-identified MSC features and performance criteria. The correlations provide evidence that satisfaction and usability, as they relate to MSCs, are closely related concepts (Friesen *et al.*, 2015a, b). Similar correlations between satisfaction

and usability are reported elsewhere (Lenker *et al.*, 2005; Arthanat *et al.*, 2009). The eMAST 1.0 may therefore provide a means to further explore this relationship, and give greater insight into issues of dissatisfaction and non-use of MSCs identified previously (Harvey *et al.*, 2012; Friesen *et al.*, 2015c).

Study limitations

The study had three main limitations: sample size, representativeness of the sample, and test-retest intervals. The sample sizes for test-retest reliability, internal consistency, and convergent validity were all within the range of 24-36 participants considered appropriate for initial scale development (Johanson and Brooks, 2010). However, small sample sizes do not allow for a full exploration of psychometric properties such as factors structures (Portney and Watkins, 2009). Further studies with larger samples are therefore recommended to confirm the psychometric properties reported here, allow for generalisations to larger populations of adults with SCI, and facilitate exploration of additional psychometric properties (Johanson and Brooks, 2010; Portney and Watkins, 2009).

Some authors argue that the representativeness of a sample has a larger impact on study parameters than sample size (Johanson and Brooks, 2010). The representativeness of the sample in this study was mixed. The sample's ratio of males to females (1.9:1) was smaller than previously reported Australian estimates of 2.5:1-5.3:1 (Australian Institute of Health and Welfare (AIHW), 2010). In addition, no data were collected from adults with SCI residing in Northern Territory, South Australia, or Western Australia, despite both Northern Territory and Western Australia having three-year annual average incidence rates of SCI that are significantly higher than the national incidence rate (AIHW, 2010). Since calls for participants went to national listservs and advertisements, it is unclear why this occurred. Further, no question on the age of participants was included on the survey form. As a result, the sample's representativeness in terms of age could not be established. Caution should therefore be exercised in generalising results of this study to broader samples of adults with SCI.

Despite these limitations, one strength of the study was its representativeness in terms of levels of SCI reported by participants. The distribution of SCI levels in the sample was consistent with Australian data showing the highest frequency of SCIs occur at or above C5 (AIHW, 2010; Harvey *et al.*, 2012), and the second highest frequencies occur between T2 and T12 (Harvey *et al.*, 2012). Neurological level of SCI is a primary predictor of the severity of bowel dysfunction after SCI, and also of functioning and AT use for self-care activities (Consortium for Spinal Cord Medicine, 1998; Ford *et al.*, 2014; Spinal Outreach Team, 2013). Both appear to directly influence MSC use and usability (Friesen *et al.*, 2013, 2015c). Future studies should aim to recruit samples of adults with SCI that are more fully representative of the population.

A final limitation was the time interval for test-retest reliability. The study aimed for an interval of seven days, which was selected based on earlier validation work with the QUEST 2.0 (Demers *et al.*, 2002a). However, the average measured interval was 14 days, with one respondent taking 43 days despite multiple attempts at follow up. Reason for delays were not explored as part of the study. As noted in the Discussion, it is possible that participants experienced temporary or unexpected changes affecting MSC use and usability during this time, thereby affecting the statistical analyses. These factors require further exploration in future studies.

Conclusions

The eMAST 1.0 was developed as a self-report instrument for adults with SCI, to measure the usability of MSCs. In this study, the eMAST 1.0 demonstrated strong internal consistency, good test-retest reliability, and strong positive correlations with the devices subscale of the QUEST 2.0, and the modified SUS. Although preliminary, this psychometric analysis suggests the eMAST 1.0 is a valid and reliable scale for measuring MSC usability in adults with SCI. Further validation studies are needed. Studies should aim to include larger samples of adults with SCI that are representative of the Australian population in terms of gender, age, and state of residence. Future studies should also consider the clinical utility of items when assessing their psychometric properties.

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